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TECHNICAL REPORT
NATICK/TR-83/038

AN IN-PORT FEEDING SYSTEM FOR SHIPBOARD PERSONNEL
VOLUME 4
RECOMMENDED QUALITY CONTROL REQUIREMENTS FOR A CENTRAL FOOD SERVICE SYSTEM

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QUALITY CONTROL	CENTRAL FOOD PREPARATION FACILITY

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains recommended quality control requirements needed to support a proposed US Navy central foodservice system where products are to be prepared centrally and distributed to satellite outlets for heating, serving and consumption. It is proposed that a hazard analysis critical control point (HACCP) evaluation be utilized to insure that foods produced and consumed are of high nutritional and sensory quality as well as safe from pathogenic foodborne microorganisms. This report is volume 4 of a four-volume series. The other titles are volume 1, An In-Port Feeding System for Shipboard Personnel; volume 2, A

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20. ABSTRACT (continued)

cost Benefit Analysis of the Use of Convenience Foods in a Military Foodservice Operation; and volume 3, A Personnel, Equipment and Facility Evaluation of the Enlisted Dining Facilities at NAS North Island and NAVSTA San Diego.

PREFACE

During FY80 to FY82 the Operations Research and Systems Analysis Office at the US Army Natick Research and Development Laboratories (NLABS) conducted an investigation of the Navy in-port feeding system under Task AA, Project 1L162724AH99A, Analysis and Design of Military Feeding Systems, of the DoD Food Research Development Testing and Engineering Program. The military service requirement identification was USN 9–2 In-port Feeding Systems for Shipboard Personnel. The purpose of this project was to develop and evaluate analytically alternative foodservice system concepts for providing meals to surface ship crew members during extended in-port periods. In particular, a system was desired to reduce onboard foodservice personnel labor requirements to provide the cooks time for leave, liberty, and training comparable with that enjoyed by other members of the crew, and, secondly, to reduce the loss of ships' force overhaul productivity resulting from messing delays. In addition, the proposed system was to provide highly acceptable and nutritious meals at a quality level that was equal to or better than that presently being served to shipboard personnel while in port.

As a means of reducing shipboard foodservice labor requirements during extended in-port periods, the use of convenience foods was proposed (see volume 1 in this series, NATICK/TR–83/035). In the event that these convenience foods are preprocessed centrally at an existing Naval dining facility and transported to satellite foodservice outlets (volume 3, NATICK TR/037), rather than purchased commercially, appropriate quality control requirements are necessary to insure food quality and safety. Therefore, to satisfy this requirement an Intergovernmental Personnel Act was granted to Dr. Ronald Josephson and Ms. Bonnie Sattler, San Diego State University, San Diego, CA to identify and develop quality control methodologies to support both the central food preparation facility and satellite outlets.

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RECOMMENDED QUALITY CONTROL REQUIREMENTS FOR A CENTRAL MILITARY FOOD SERVICE SYSTEM

I. INTRODUCTION

These recommendations on quality control are part of a comprehensive study by the US Army Natick Laboratories (NLABS) to evaluate the potential of utilizing centralized food preparation for Navy foodservice feeding in San Diego. Preparation of foods at a central facility for distribution and service at remote sites has been successful, in many applications, through the following means: (1) lowering overall food costs through volume purchasing; (2) minimizing duplication of labor, space and equipment at the remote site(s); (3) allowing more efficient labor schedules through meeting future production rather than daily needs; and (4) reducing requirements for highly skilled workers at the remote site(s).[1]

Three variations of food storage are possible in a commissary food service system: cook-hot-hold, cook-chill, and cook-freeze.[1] Hot-holding of precooked foods for service at remote sites may require several hours of storage at elevated temperatures, which can reduce product quality and enhance the possibility for growth of pathogenic microorganisms. Therefore, it is not a good choice for commissary food service systems. Previous work done by NLABS at Fort Lewis, Washington, showed that cook-chill or cook-freeze systems could be effectively used, but that modifications from standard armed service menus and recipes must be made to meet the needs of large-scale centralized preparation and to minimize instability problems caused by chilled or frozen storage.[2] There have been several recent reviews of food freezing or cook-freeze systems that have made specific recommendations for minimizing food instability, safety, and quality problems.[3,4,5,6]

[1] N.F. Unklesbay, R.B. Maxcy, M.E. Knickrehm, K.E. Stevenson, M.L. Cremer, M.E. Matthews. Foodservice Systems: Product Flow and Microbial Quality and Safety of Foods. Research Bulletin, Agricultural Experiment Station, University of Missouri (1977).

[2] D.B. Rowley, J.M. Tuomy, and D.E. Westcott. Fort Lewis experiment application of food technology and engineering to central preparation. NATICK/TR–72–46–FL. 1972 (AD 739 499)

[3] G. Glew. Cook/Freeze Catering, London: Faber and Faber, 1973.

[4] B. Boltman. Cook/Freeze Catering Systems, London: Applied Science Publishers, Ltd., 1978.

[5] P.M. Cox. Deep Freezing – A Comprehensive Guide to Its Theory and Practice. London: Faber and Faber, 1979.

[6] N.W. Desrosier and K.D. Tressler. Fundamentals of Food Freezing, Westport, CN: AVI Publishing Co., Inc., 1977.

Relatively little data exist on the effects of cook-chill or cook-freeze systems on nutritional value, but the evidence available indicates that vitamin retention is generally similar to that for conventional food service.[7,3] However, long-term storage, excessive heating and hot-holding can have a negative effect on heat-labile vitamins (Vitamin C, thiamine, etc.), compounding the losses that occur during thawing (drip loss) and cooking.[8]

The proposed military foodservice system in San Diego would primarily be a cook-freeze system.[9] Therefore, the emphasis of this report will be placed on problems envisioned from the adoption of a cook-freeze food system. In a cook-freeze system, food is prepared in bulk, packaged, frozen rapidly, and stored frozen until reheated for service.

Changes in flavor and texture are major problems in a cook-freeze food service system. These problems can result from slow freezing, high or fluctuating freezer temperatures, long storage times, or slow thawing.[3,6] These defects can be minimized with recipe reformulation and with proper packaging, freezing, storing and thawing practices.

Another major problem of cook-freeze and cook-chill systems is the potential for contamination and growth of pathogens. Both of these systems require more extensive food handling and longer storage times (weeks or days, respectively) than does a conventional cook-serve system. In fact, the major causes of foodborne illness in the US have been traced to inadequate cooling of foods and to the storage of foods for a day or longer with inadequate refrigeration and/or hot-holding during the storage time.[10,11]

In order to maintain safe high quality foods, the concept of Hazard Analysis and Critical Control Points (HACCP) has been recently recommended as a major quality control measure

[7] G.E. Livingston, C. Ang, and C.M. Chang. Effects of Foodservice Handling. Food Technology, 27:1; 36 (1973).

[8] J.W. Erdman, Jr. Effect of preparation and service of food on nutrient value. Food Technol., 33(2): 38—48 (1979).

[9] M. Davis. Personal communication. US Army Natick Research and Development Laboratories, Natick, MA (1981).

[10] F.L. Bryan. Foodborne diseases in the United States associated with meat and poultry. J. Food Protection, 43:140–150 (1980).

[11] O.P. Snyder. A model food service quality assurance system. Food Technol., 35(2):70–76 (1981).

for foodservice systems.[12,11,13] Hazard analysis basically involves: (1) identifying foods and ingredients that are potentially hazardous because they contain or could support growth of pathogenic foodborne microorganisms or poisonous substances; (2) determining sources and specific points of contamination, survival and growth of pathogens during food service operations; and (3) implementing measures to eliminate avoidable hazards or minimizing hazards to acceptable limits. Critical control points are established for those phases of the operation where lack of control may cause a public health hazard. Frank L. Bryan, Chief of Foodborne Disease Training at the Center for Disease Control in Atlanta, has recommended (1981) the HACCP system as the best available insurance policy for prevention of foodborne illness in foodservice operations.[12]

II. OBJECTIVES

The overall purpose of this project is to determine the appropriate quality control requirements to insure that foods produced and consumed are of high nutritional and sensory quality as well as safe from pathogenic foodborne microorganisms.

The proposed military foodservice system will feed shipboard personnel at remote sites when their ships are in port for extended periods. The location of the central food preparation area will be the US Navy's NAS North Island facility, which is equipped with high volume production equipment. Facilities for freezing and frozen storage will be added if the proposed commissary foodservice system is implemented.

A 21-day standard menu has recommended for utilization in a future Navy foodservice feeding system (see Volume 2 in this series, A Cost Benefit Analysis of the Use of Convenience Foods in a Military Foodservice Operation by Mary Q. Hawkins, NATICK/TR–83/036). The six specific quality control objectives of this project, listed below, apply to major menu categories (entrees, starches, salads, desserts) and, as necessary, to individual items. These objectives are

(1) To determine types of, frequency of, and locations of various quality control procedures at the central food preparation facility and remote sites;

(2) To determine the equipment requirements needed to perform the necessary quality control procedures identified;

(3) To determine the qualifications and number of personnel to perform the quality control procedures;

[12] F.L Bryan. Hazard analysis of food service operations. Food Technol., 35(2):78–87 (1981).

[13] B.J. Bobeng and B.D. David. HACCP models for quality control of entree production in foodservice systems. J. Food Protection, 40:632–638 (1977).

(4) To recommend methods of storage and transportation to maintain quality and safety of foods;

(5) To recommend possible alternatives to existing menus that are more compatible with the proposed commissary food service system;

(6) To estimate the costs of equipment and personnel required in the proposed quality control system.

III. GENERAL FOOD SERVICE SANITATION PRACTICES

Preparation of safe and nutritious foods requires strict adherence to the most-recommended sanitation practices available. Therefore, it is recommended that the general guidelines of the Food and Drug Administration's "Food Service Sanitation Manual" be adopted for the proposed Navy Commissary food service system.[14] The provisions provide information and guidelines for: (1) protection, storage, preparation, display, service, and transportation of food; (2) handling, cleaning, sanitizing, and storage of equipment and utensils; (3) maintenance of the physical facilities and mobile food units; and (4) personal sanitation of food handlers. Also, recommended as a general reference source, is the textbook of Longree (1980), which presents a thorough coverage of areas of sanitation and microbiological control practices in food service systems.[15]

IV. OVERALL QUALITY CONTROL ANALYSES

It is proposed that a hazard analysis critical control point (HACCP) evaluation be used in the proposed Navy centralized food service system in San Diego. The whole operation, from procurement to service of food, must be evaluated for hazardous foods and procedures. Forms developed by the Center for Disease Control[12] can be adapted, with modifications for cook-freeze methodologies (see Figures 1 and 2). In Part 1 of the report form (Figure 1), one food or a group of foods are identified and a diagram of the flow process is detailed. Information is given on sources of potential contamination, time-temperature exposures, practices leading to survival and growth of pathogenic microorganisms, and on critical control points and measures for prevention and control. The second from (Figure 2), outlines the typical flow processes in foodservice operations and sanitary practices that, if deficient, could cause foodborne disease outbreaks.

[14] U.S. Dept. HEW. Food Service sanitation manual. HEW Pub. No. (FDA) 78–2081, U.S. Govt. Printing Office, Washington, DC (1976).

[15] K. Longree. Quantity Food Sanitation. Wiley-Interscience, New York (1980).

Part 2. Evaluation of Specific Hazards

THE ITEMS CIRCLED BELOW IDENTIFY DEFICIENCIES IN OPERATIONS

1. ☐ Procuring and Receiving

a. Water and ice are from unsafe, unprotected, or unapproved source(s).
b. Raw milk is purchased or used.
c. Shellfish is from unapproved or unknown source(s).
d. Canned foods are purchased or otherwise obtained from home(s) or other unapproved source(s).
e. Swollen canned foods are received.
f. Mushrooms are gathered from fields or woods or obtained from other unapproved source(s).
g. Meat or meat products are from uninspected or unapproved source(s).
h. Cracked or checked eggs are purchased or received.
i. Incoming foods and ingredients do not meet microbiological specifications.

2. ☐ Storing Packaged and Raw Foods

a. High-acid (pH 4.5 or lower) foods are stored in containers or conveyed in pipes made of metals or alloys that contain or are coated with toxic materials, such as antimony, cadmium, copper, lead or zinc.
b. Foods are packaged in materials containing toxicants that could migrate to foods.
c. Poisonous substances are stored in the same room as foods.
d. Poisonous substances are either not labeled or are improperly labeled.
e. Unapproved pesticides are used or pesticides are applied in a manner that could contaminate foods or lead to their contamination.
f. Poisons (such as pesticides and cleaning agents) are stored in used-food containers or containers sometimes used to store foods.
g. Foods are subjected either to: (1) sewage drippage, overflow, or backflow; (2) exposure to water or moisture during storage; or (3) exposure to contamination by insects or rodents.

3. ☐ Reconstituting or Thawing Foods

a. Dry foods are contaminated during reconstitution by (1) nonpotable water, (2) workers' hands, or (3) utensils.
b. Foods are not properly thawed before cooking (other than items of 1.4 kg/3 lb or less which can be thawed during cooking.
c. Method of thawing not proved to be effective for thawing type of food (raw or cooked) or size, volume, or weight of item.
d. Thawed foods are left at room temperature.

4. ☐ Handling and Preparing Raw Foods

a. Workers do not wash hands (generate lather) after handling raw animal products (meat, poultry, eggshells, or fish).
b. Raw foods are processed in or on equipment or with utensils that are used subsequently for foods that will not be cooked or reheated (without intervening cleaning).
c. Raw beef, lamb, or other meat are ground in the same grinder that had been used for grinding raw pork without thorough cleaning between operations.
d. Chemicals or food ingredients (such as monosodium glutamate or sodium nitrite) that produce toxic reactions in man are added to foods at levels exceeding culinary requirements during preparation or in known hazardous levels

5. ☐ Cooking

a. Poultry, poultry products, foods containing poultry, or poultry dressing are not cooked to an internal (geometric center) temperature of at least 74°C/165°F.
b. Pork, pork products, or foods containing pork are not cooked to an internal (geometric center) temperature of at least 66°C/150°F.

6. ☐ Handling Cooked Products

a. Cooked foods have contact with raw animal products.
b. Cooked foods are processed on the same equipment or stored in the same containers previously used for raw animal products, without thorough cleaning and sanitizing between each usage.
c. Cooked foods are contaminated by thaw water, drip water, or aerosols from raw animal products.
d. Workers touch cooked foods with bare hands.

7. ☐ Hot Holding

a. Foods are put into hot-holding devices at temperatures below 54°C/130°F, unless hot holding has been proved to be an integral part of post-heating temperature rise in the food.
b. Foods held in hot-holding devices are at temperatures below 54°C/130°F.

8. ☐ Cooling

a. Cooked foods that have either (1) a pH above 4.5 or (2) a water activity (a_w) above 0.85 or (3) a pH above 5 and a water activity above 0.90 are kept at room temperature for 1 hour or more.
b. Solid or semi-solid cooked foods are stored in refrigerators at a depth greater than 10 cm/4 in.
c. Containers that have a height greater than 10 cm/4 in are used to store solid or semi-solid cooked foods.
d. Cooked foods (as defined in 7a) are not cooled rapidly to 21°C/70°F within 2 hours.
e. Cooked foods (as defined in 7a) stored in refrigerators do not reach 7°C/45°F within 6 hours after removal from cooking or hot-holding devices.

9. ☐ Reheating

a. Foods of a quantity greater than 1.4 kg/3 lb are (1) cooked on a preceding day, (2) cooked several hours before serving on the same day, or (3) left over from previous meals and not reheated to a temperature at the geometric center of less than 71°C/160°F.
b. Foods of a quantity less than 1.4 kg/3 lb, but otherwise complying with the above definition, are reheated to a temperature at the geometric center of less than 74°C/165°F.

10. ☐ Serving

a. Workers touch foods during serving.
b. Foods are otherwise contaminated during serving. (Specify below.)

11. ☐ Cleaning and Sanitary Maintenance

a. Kitchen equipment (such as slicers, grinders, cutting boards, storage pots or containers, and preparation utensils) are ineffectively washed, rinsed, or sanitized.
b. Equipment and utensils are not thoroughly cleaned and sanitized after contact with raw animal products.
c. Cloths and sponges are used to clean preparation surfaces used for raw foods and then are used to wipe surfaces that are to be used for foods that will not be cooked or reheated.
d. A sanitary maintenance schedule has not been established and is not in use for all pieces of equipment used for preparation.

12. ☐ Hygiene of Workers

a. Persons who have diseases that can be transmitted by foods or who have symptoms (diarrhea, fever, rhinorrhea, jaundice, sore throat) or diseases (colds or sinusitis) that promote the spread of foodborne pathogens or who are infected with certain pathogens (*Shigella* spp., *Salmonella typhi*, or others designated by the health officer to be transmitted by foods) handle foods.
b. Workers who have infected lesions (boils and other pus-containing lesions) touch potentially hazardous foods.
c. Workers do not wash hands thoroughly (generate lather) after using toilet, smoking, sneezing, coughing, blowing or picking nose, or touching sores or bandages.
d. There are either no facilities or inadequate facilities (lavatory without hot water, no soap, no single-service towels) in food preparation area for hand washing.
e. Toilet facilities are inadequate or not functioning.
f. Sewage disposal facilities are inadequate or unapproved.

13. ☐ Management

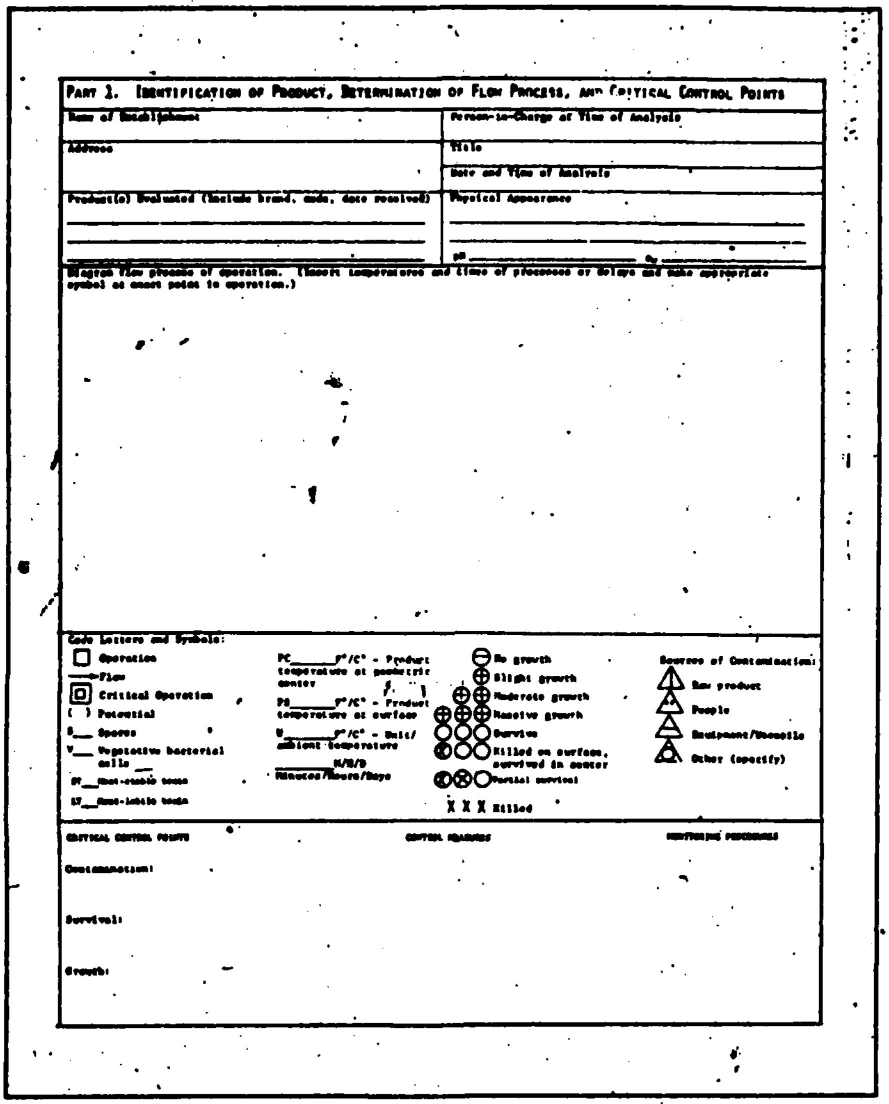
a. Managers are not trained or do not demonstrate proficiency in knowledge of foodborne disease hazards or their prevention.
b. Managers either have not trained or do not supervise staff in foodborne disease hazards and their prevention.
c. A system for control has not been established or initiated for all hazards that have been identified previously.

Illustrate hazards and specify critical control points dealing with contamination, survival, and growth on the reverse side.

Other deficiencies or further comments and recommendations:

Name of Person Making Analysis	Title and Agency

Figure 1. Food service hazard analysis report form, Part 1 (Bryan, 1981)[12]



PART 1. IDENTIFICATION OF PRODUCT, DETERMINATION OF FLOW PROCESS, AND CRITICAL CONTROL POINTS

Person-in-Charge at Time of Analysis

Title

Date and Time of Analysis

Physical Appearance

pH

symbol at exact point in operation.)

Code Letters and Symbols:

Operation

Flow

Critical Operation

( ) Potential

S___ Spores

V___ Vegetative bacterial cells

PC_______F°/C° - Product temperature at geometric center

PS_______F°/C° - Product temperature at surface

U_______F°/C° - Unit/ambient temperature

_______M/H/D Minutes/Hours/Days

No growth

Slight growth

Moderate growth

Massive growth

Survive

Killed on surface, survived in center

Partial survival

X X X Killed

Sources of Contamination:

Raw product

People

Equipment/Utensils

Other (specify)

Survival:

Growth:

Figure 2. Food service hazard analysis report form, Part 2 (Bryan, 1981)[12]

V. PRODUCTION OF COMMISSARY FOODS

Table 1 lists standard menu items previously recommended in the current Natick research study for use by the US Navy in San Diego. The foods have been categorized according to food-type (entree, etc.) and to appropriate food preparation, storage, and service method. Food items identified as potentially hazardous have been designated for HACCP quality control. Additional data include production quantities (required for 1,000 servings based on Armed Forces recipe standards) and suggested preparation, storage, and service methods. The figure of 1,000 servings was suggested as an appropriate number for the proposed commissary system in San Diego.[9] Suggested recipe modifications are also included to provide guidelines for reformulation of standard Armed Forces recipes.

Product flow charts (Figure 3) are given for the four major food categories that would involve preparation and handling at the central food preparation facility (CFPF) prior to transportation to a remote site for service. There may be exceptions for certain foods within each category – for example, commercially canned or frozen foods may be sent directly from central supply to the remote site.

VI. BASIS FOR SELECTION OF FOODS FOR HAZARD ANALYSIS

Foods were generally selected for Hazard Analysis (HACCP) monitoring on the basis of one of the following:

(1) Foods previously documented as a source of foodborne disease; foods of animal origin, such as meat or poultry, and products containing them have been documented as the source of over half the reported outbreaks when the source was discovered;[10]

(2) Foods that through their normal composition and physical properties (pH, water activity, etc.) support growth and multiplication of foodborne pathogenic microorganisms;

(3) Foods that at any step of processing and preparation will be subject to (a) addition of ingredients; (b) contact with equipment, utensils, or human hands; or (c) holding products within the critical temperature zone of 40°F to 140°F (5°C to 60°C) for several hours;

(4) Foods, such as desserts, that are prepared from scratch at the central facility and served at the remote site (see Table 1, Part D); the high starch content of these products, favorable pH, contact with human hands, and absence of post-processing heat treatment, together with time-temperature abuse may contribute to outbreaks;

(5) Foods that are commercially prepared, such as canned soups, canned or frozen vegetables, or dry dessert mixes would, in general, be exempt from microbial sampling, but must meet basic military food quality standards.

Table 1

Part A. Entrees: quantities required, preparation storage, and service method, recipe modification; and hazard identification

Entrees	Quantities Required[a,b]	Preparation, Storage, and Service Method: Central Food Preparation Facility	Preparation, Storage, and Service Method: Remote Site	Recipe Modification	Hazard Identification (HACCP)[c]
Roast Beef	188 lb	Cook, freeze[d]	Heat, serve[d]		x
Roast Turkey	125 lb	Cook, freeze[d]	Heat, serve[d]	j	x
Pork Loin/Gravy	157 lb	Cook, freeze[d]	Heat, serve[d]		x
Braised Short Ribs	500 lb	Prepare, cook, freeze	Heat, serve	k	x
Swiss-Steak	313 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k	x
Beef Stew	375 lb	Prepare, cook, freeze[d]	Heat, serve[d,g]	k	x
Meatloaf	313 lb	Prepare, cook, freeze[d]	Heat, slice, serve[d]		x
Veal Foldover	625 lb	Prepare, cook, freeze	Heat, serve		x
Lasagna	500 lb	Prepare, cook, freeze	Heat, serve		x
Macaroni and Cheese	500 lb	Prepare, cook, freeze[d]	Heat, serve[d,h]	k	
Pork/Chicken Chow Mein	375 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k	x
Turkey Tetrazini	500 lb	Prepare, cook, freeze[d]	Heat, serve[d,h]	k	x
Salisbury Steak	313 lb	Prepare, cook, freeze[d]	Heat, serve[d]		x
Pizza Patty	250 lb	Recipe unavailable			x
Veal Parmeson	313 lb	Prepare, cook, freeze[d]	Heat, serve[d]		x
Hot Roast Beef Sand.	188 lb (beef)	Cook, slice, freeze[d]	Heat, combine, serve[d]	k	x
Cod/Lemon Sauce	313 lb	Recipe unavailable			x
Fish/Creole Sauce	313 lb	Prepare sauce, freeze	Combine, cod, serve		x
Sloppy Joe/Bun	125/lb/84 dz	Prepare, cook, freeze	Heat, combine serve		x
Spaghetti/Meat Sauce	63 gal/375 lb	Prepare, cook, freeze separately[d]	Heat, serve[d,h]		x
Beef Enchiladas	167 oz	Prepare, freeze[f]	Cook, serve[f]		x
Stuffed Peppers	500 lb	Prepare, freeze[e]	Cook, serve[e]		x
Baked Chicken/Mushroom Soup	500 lb	Prepare, cook, freeze[d]	Heat, serve[d]		x
Pepper Steak	375 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k	x
Marinated Scallops/Shrimp/Rice	625 lb	Prepare, cook, chill			x
Chili	500 lb	Prepare, cook, freeze[m]	Heat, serve[m]		x
Veal Cordon Bleu	250 lb	Prepare, cook, freeze[d]	Heat, serve[d]		x

Table 1

Part A. Entrees: quantities required, preparation storage, and service method, recipe modification; and hazard identification (cont'd)

Entrees	Quantities Required[a,b]	Preparation, Storage, and Service Method: Central Food Preparation Facility	Preparation, Storage, and Service Method: Remote Site	Recipe Modification	Hazard Identification (HACCP)[c]
Meatballs Polynesian	375 lb	Prepare, cook, freeze	Heat, serve	k	x
Hungarian Goulash	375 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k	x
Sliced Beef/Gravy	500 lb	Prepare, cook, slice, freeze[d]	Heat, serve[d]	k	x
Hot BBQ Sandwich	188 lb	Prepare, cook, slice, freeze[d]	Heat, combine, serve[d]		x
Swedish Meatballs	375 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k	x
Stuffed Cabbage Rolls	500 lb	Prepare, freeze	Cook, serve		x
Macaroni/Beef/Tomatoes	500 lb	Prepare, cook, freeze	Heat, serve[h]		x
Corned Beef	157 lb	Cook, chill[f]	Heat, slice, serve[f]		x
Beef Stroganoff	375 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k,l	x
French Bread Pizza	375 lb	Prepare, freeze[f]	Cook, slice, serve[f]		x
Cheese/Sausage Pizza	14 dz	Prepare, cook, freeze[f]	Heat, cut, serve[f]		x
Chicken ala King	375 lb	Prepare, cook, freeze[d]	Heat, serve[d]	k	x
Breaded Pork Chops	313 lb	Prepare, freeze[f]	Cook, serve[f]		x
Fried Chicken	625 lb	Prepare, freeze[f]	Cook, serve[f]		x
Chicken Fried Beef Patty	375 lb	Prepare freeze[f]	Cook, serve[f]		x
Ham Steak	219 lb	Slice[e]	Cook, serve[e]		x
Fried Perch	313 lb		Cook, serve[f]		x
Fried Fish Square	250 lb		Cook, serve[f]		x
Fried Scallops	250 lb		Cook, serve[f]		x
Baked Ham	183 lb		Cook, slice, serve[e]		x
Minute Steak	250 lb		Cook, serve[f]		x
Seafood Newburg	375 lb	Prepare, cook, chill	Cook, serve[f]		x
Grill Steak	375 lb				

[a]For 1,000 servings based on Armed Forces Recipe Service.[16]

[b]Total ounces required are expressed in volume units for all items except those given in pounds (weight basis).

[c]Based on criteria described elsewhere in this report.

[d][17].

[e][16].

[f][2].

[g]Undercook vegetables to avoid overcooking when heated.[5,18]

[h]Undercook pasta to avoid overcooking when heated.[5,18]

[i]Egg yolk sauces do not freeze well.[5]

[j]Turkey is prone to oxidative rancidity; simmer with antioxidants rather than roasting and remove fat before freezing.[17]

[k]Modified starch should be substituted for flour or cornstarch.[2,6,5]

[l]Substitute evaporated milk and modified cream for sour cream.[17]

[m][19].

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[16]Depts. Army, Navy, Air Force. Armed Forces recipe service. NAVSUP Publication 7. Superintendent of Documents, U.S. Govt. Printing Office, Washington, DC (1976).

[17]D.K. Tressler. Freezing of precooked and prepared foods. AVI Publishing Co., Inc., Westport, CN (1968).

[18]C.C. Peckham. Foundations of food preparation. Macmillan Publishing Co., Inc., New York (1974).

[19]D.B. Marsh. The new good housekeeping cookbook. Harcount, Brace and World, New York (1963).

Table 1

Part B. Starches: quantities required, preparation — storage, and service method, recipe modifications; and hazard identification

Starches	Quantities Required[a,b]	Preparation, Storage, and Service Method: Central Food Preparation Facility	Preparation, Storage, and Service Method: Remote Site	Recipe Modification	Hazard Identification (HACCP)[c]
Rice	42 gal	Cook, freeze[d]	Heat, serve[d]		
Mashed Potatoes	31 gal		Prepare, cook, serve[e]		
Sweet Potatoes	31 gal	Cook, freeze[f]	Heat, serve[f]	j,k	
Buttered Noodles	31 gal	Cook, freeze[f]	Heat, serve[f]	g	
Potato Nuggets	250 lb		Cook, serve[h]		
French Fried Potatoes	188 lb		Cook, serve[h]		
Refried Beans	40 #10 cans		Heat, serve		
Scalloped Potatoes	313 lb	Prepare, cook, freeze[h]	Heat, serve[h]		
Baked Potato	375 lb		Cook, serve		
Hash Browns	250 lb	Prepare, freeze[d]	Cook, serve[d]		
Delmonico Potatoes	250 lb				
AuGratin Potatoes	250 lb	Prepare, cook, freeze[h]	Heat, serve[h]		
Noodles Romanoff	31 gal	Prepare, cook, freeze[f]	Heat, serve[f]	g	
Candied Sweet Potatoes	31 gal	Prepare, cook, freeze[f]	Heat, serve[f]	j	
Bread Dressing	31 gal	Prepare, cook, freeze[i]	Heat, serve[i]		
German Potato Salad	31 gal	Prepare ingredients	Cook, serve		

[a]For 1,000 servings based on Armed Forces Recipe Service standards.[16]

[b]Total required ounces are expressed in volume units for all items except those given in pounds (weight basis).

[c]Based on criteria described elsewhere in this report.

[d][17].

[e]Mashed potatoes become soggy and develop warmed-over flavor when frozen and reheated.[6]

[f][18].

[g]Undercook pasta to avoid overcooking when heated.[5,18]

[h][6].

[i][5].

[j]Undercook vegetables to avoid overcooking when heated.[5,18]

[k]Mix with one half cup lemon or orange juice before freezing to prevent browning.[20]

[20]Ball Corporation. Ball Blue Book. Ball Corporation, Muncie, IN (1974).

Table 1

Part C. Salads: quantities required, preparation storage, and service method, recipe modifications; and hazard identification

Salads	Quantities Required[a,b]	Preparation, Storage, and Service Method: Central Food Preparation Facility	Preparation, Storage, and Service Method: Remote Site	Recipe Modification	Hazard Identification (HACCP)[c]
Tossed Green	110 lb	Prepare ingredients, chill[d]	Combine, serve[d]	e	
Cole Slaw	31 gal	Prepare cabbage, dressing[f]	Combine, serve[f]		
Fruit	31 gal				
Potato	31 gal	Prepare ingredients, chill[f]	Combine, serve[f]		x
Macaroni	31 gal	Prepare ingredients, chill[f]	Combine, serve[f]		
Carrot/Raisin	31 gal	Prepare ingredients, chill[f]	Combine, serve[f]		
Marinated Cucumbers	31 gal	Prepare cucumbers, marinate	Serve		
Three Bean	31 gal	Prepare, chill[f]	Serve[f]		
Cottage Cheese/Fruit	120 lb/20 #10 cans		Prepare, serve[f]		
Vegetable/Fruit Gelatin	25 pans 12 x 20"	Prepared, chill	Serve[f]		
Cranberry Relish	31 gal	Prepare, chill[f]	Serve[f]		
Apple Salad	31 gal	Prepare ingredients, chill[f]	Combine, serve[f]		
Relish Plate	125 lb	Prepare ingredients, chill[f]	Portion, serve[f]		
Tomato Slices	Varies		Prepare, serve[f]		
Marinated Tomatoes	Varies	Prepare marinade	Prepare tomatoes, combine, serve[f]		
Whole Fruit	1000 pieces		Wash, serve[f]		
Applesauce	40 #10 cans		Serve		
Waldorf	31 gal	Prepare ingredients, chill[f]	Combine, serve[f]		
Fruit/Grated Cheese	20 #10 cans/ 4 gal	Grate cheese, chill[f]	Prepare, serve[f]		

[a]For 1,000 servings based on Armed Forces Recipe Service standards.

[b]Total ounces required are expressed in volume units for all items except those given in pounds (weight basis).

[c]Based on criteria described elsewhere in this report.

[d][2].

[e]Soak greens in anti-oxidant solution.[2]

[f]Quality deterioration precludes freezing or long-term chilled storage.[17,18]

Table 1

Part D. Desserts: quantities required, preparation storage, and service method, recipe modifications; and hazard identification

Desserts	Quantities Required[a]	Preparation, Storage, and Service Methods: Central Food Preparation Facility	Remote Site	Recipe Modification	Hazard Identification (HACCP)[b]
Fruit Pies	11 dz	Prepare, freeze[c]	Bake, serve[c]	e	
Pumpkin Pie	11 dz	Prepare, bake, freeze[c]	Thaw, serve[c]		
Pecan Pie	8½ dz				
Cakes	7 dz	Prepare, bake, freeze[c]	Thaw, serve[c]	g	
Fruit Crisp	10 bun pans	Prepare, bake, freeze[c]	Thaw, serve[c]		
Cookies	167 dz	Prepare, bake, freeze[c]	Thaw, serve[c]		
Brownies	13 bun pans	Prepare, bake, freeze[c]	Thaw, serve[c]		
Cut/Whole Fruit	varies		Prepare, serve		
Fruit Cobbler	42 cobblers	Prepare, bake, freeze[c]	Thaw, serve[c]		
Cornstarch Puddings	31 gal	Prepare, chill[c]	Serve[c]	f	x
Tapioca Pudding	31 gal	Prepare, chill[c]	Serve[c]		x
Date Pudding/Whipped Cream	250 lb/gal	Prepare, chill[c]	Serve[c]		x (cream only)
Cream Pies	11 dz	Prepare, chill[c]	Serve[c]		x
Custard Pie	11 dz	Prepare, chill[c]	Serve[c]		x
Lemon Meringue Pie	11 dz	Prepare, chill[c]	Serve[c]		x (meringue)
Boston Cream Pie	7 dz	Prepare, chill[c]	Serve[c]		x
Custard	31 gal	Prepare, chill[d]	Serve[d]		x
Pastries	84 dz	Varies	Varies		x
Gelatin/Whipped Cream	41 gal/4gal	Prepare, chill	Serve		x (cream only)
Cheesecakes	11 dz	Prepare, bake, freeze[c]	Thaw, serve[c]		
Chocolate Eclair	84 dz	Prepare, chill[c]	Serve[c]		x
Fruit Shortcake	varies	Prepare cake, fruit, chill	Combine, serve		
Rice Pudding	31 gal	Prepare, chill[c]	Serve[c]		x

[a]For 1,000 servings based on Armed Forces Recipe Service standards.[16]

[b]Based on criteria described elsewhere in this report.

c[17].

d[21].

[e]Use modified starch or tapioca in place of flour for thickening.[17]

[f]May be reformulated for freezing.[17]

[g]Use emulsifier and dough conditioners.[2]

[21] J.C. Gates. Basic foods. Holt, Reinhart and Winston, New York (1976).

Location	Entrees	Starches	Salads	Desserts
1. Supply Center: (raw product storage)	x	x	x	x
2. Central Food Processing Facility (CFPF):				
Storage	x	x	x	x
Preparation	x	x	x	x
Cooking	x	(x)[a]	(x)[b]	x(or baking)
Packaging	x	x	x	x
Freezing	x	x		(x)[c]
Storage				
(frozen)	x	(x)[a]		(x)[c]
(chilled)			x	(x)[c]
(ambient)				(x)[c]
3. Remote Site:				
Storage				
(frozen)	x	(x)[a]		
(chilled)			x	
(ambient)				(x)[c]
Thawing	x	(x)[a]		(x)[c]
Reheating	x	x		
Other	(slicing of meat)		(adding dressing or portioning)	
Service	x	x	x	x

[a]Exceptions noted in Table 1.

[b]Only for potato or macaroni.

[c]Varies according to types of dessert (see Table 1).

Figure 3. Product flow chart for foods processed in a commissary central food preparation facility

VII. MICROBIOLOGICAL CONSIDERATIONS IN FROZEN FOODS[6,22]

Persons engaged in the freezing process face seven microbiological considerations.[6,17]

(1) Freezing does not improve the microbiological quality of a food product even though destruction of some bacteria occurs.

(2) Few microorganisms (except yeasts, molds, and some bacteria) are capable of growth at freezing temperatures.

(3) Blast freezing reduces total bacterial numbers. Fecal streptococci, staphylococci, coliforms, yeasts and molds are more susceptible than anerobes. Freezing does not make the food necessarily free of pathogenic organisms.

(4) Foodborne pathogens (**Salmonella**, Staphylococci, **Clostridium**, and **C. perfringens**) are not considered to be psychrophilic organisms and therefore are not generally capable of appreciable growth at refrigeration temperatures. However, as a word of caution, some pathogens will grow slowly at or above 3°C (38°F) as indicated in the following examples:

C. perfringens – minimum growth temperature is about 15°C (59°F)
C. botulinum –
 Types A, B (proteolytic strain), C, and D do not grow below 10°C (50°F)
 Type E and nonproteolytic strains of type B and F can grow at, but not below, 3°C (38°F)
 Langlande strain of type F (proteolytic) grow at, but not below, 3.8°C (39°F)
Staphylococci – minimum growth temperature is 4°C (40°F)
S. typhimurium – minimum growth temperature is 7°C (44°F)
S. heidelberg – no growth below 4°C (40°F); very slow growth between 4.0°C to 5.7°C (40°F–42.3°F)
Enterococci – minimum growth temperature above 10°C (50°F)
Most coliforms – no growth below 5°C (41°F)

(5) Optimum growth temperatures for most microorganisms range from 20°C to 37°C (68°F to 98.6°F).

(6) Precooking greatly reduces the microbial content of foods but does not sterilize the food. The heat-sensitive bacteria (total count, coliform count, and streptoccal counts) are reduced to a greater degree than the Enterococci, Staphylococci and anaerobes (Clostridia). Therefore, precooking does not necessarily mean that the food is free from pathogenic microorganisms.

[22] M.P. Defigueiredo and D.F. Splittstoesser. Food Microbiology: Public Health and Spoilage Aspects. The AVI Publishing Co., Inc., Westport, CN (1976).

(7) Temperature control is especially critical for frozen foods packaged in plastic packaging because of the reduced oxygen content and potential for anerobic spore formation if unexpectedly high temperatures are reached during thawing. However, it appears that ballooning and bursting would occur in the plastic pouch from putrefactive anerobes present before botulism toxin would be produced.

VIII. RECOMMENDED MICROBIOLOGICAL TESTING FOR HACCP QUALITY CONTROL

A. Food Testing

Routine microbiological testing should be conducted on all foods that have been identified as hazardous or potentially hazardous (see Table 1 for identified foods). It should be emphasized that this does not mean that strict adherence to sanitation is not necessary for all other foods. Present standards of quality dictate that all foods be not only safe for consumption but handled and prepared under aesthetically suitable conditions.[6]

Microbial tests should include, at minimum, total aerobic plate counts and coliform counts. These tests should be routinely run on all identified finished food items, and periodically at critical control points of preparation, especially when initial counts are high. It is important to note that high aerobic or coliform counts may not imply the presence of pathogens, but instead indicate unsanitary handling practices or a lack of temperature control that could permit the contamination of food and subsequent growth of microbial pathogens. Conversely, freedom from coliform counts does not necessarily indicate freedom from pathogens. Table 2 outlines the basic microbial tests recommended and justifications for their usage.

Testing for specific organisms, such as Clostridia and Staphlococci, is important because their presence could be indicative of the potential for foodborne outbreaks. Tests should be performed routinely on foods known to be a vehicle for these organisms, such as meat and poultry. Testing at critical control points throughout production, storage, and service may be necessary to locate the source(s) of contamination and to verify that high microbial levels were not present during the early stages of preparation.

Salmonella determinations cannot be recommended for in-house testing because quantifying **Salmonella** is a very complex process involving procedural steps of pre-enrichment, selective enrichment, differential and selective plating, isolation and confirmation of selected isolates. These steps are required because normally relatively small numbers of Salmonella are present in foods compared to competing microorganisms.[24] However, concern should be given to the potential problems associated with food service operations that can contribute to Salmonellosis, a foodborne infection accounting for 23% of reported outbreaks of foodborne disease in the US during the period from 1973 to 1978.[12]

Salmonella are widespread and primarily found in humans, domesticated animals, and raw meat products. Foods most implicated as vehicles of Salmonellosis in the US are beef, turkey, homemade ice cream (containing eggs), pork and chicken.[12] **Salmonella** are relatively heat-labile and can be eliminated by cooking foods to 74°C (165°F) or higher. Growth can be controlled at refrigeration temperatures below 6°C (43°F).[1] However, cooked foods can be contaminated

Table 2

Recommended microbiological tests and justifications for their use

Determination	Justification
Aerobic Plate Count [23,24]	Useful tool for estimating overall microbial population in food and points of contamination in food service operations.[24]
Coliform Count[23,24]	Indicative of unsanitary production practices and possible fecal contamination. Coliforms occur naturally in soil, and grow in and on processing equipment in the presence of food.[24]
Clostridal Count[23,24]	Indicates presence of C. perfringens, a bacterium capable of causing foodborne illness, usually found in meat and poultry products containing large numbers of viable cells. Especially a problem in cooked meat and poultry having reduced oxygen content and decreased numbers of competing organisms.[24,1]
Staphlococcal Count[23,24]	Indicates the presence of S. aureus, a heat-labile bacterium capable of producing heat-stable enterotoxins that cause food poisoning when ingested. Normally indicates postprocessing contamination from the skin, mouth, or nose of food handlers and inadequate temperature control. High protein foods of animal origin (meat, poultry, fish, eggs, and dairy products) that receive human handling are usually the common vehicles.[24,1]
Yeasts and Mold Counts[23,24]	Although present as normal flora in some foods, may indicate airborne contamination or inadequate equipment sanitation during food preparation and handling. Responsible for spoilage of many foods and can produce toxic metabolites.[24]

[23] Chipley, J.R. and M.L. Cremer. Microbiological problems in the food service industry. Food Technol., 34(10):59–68 & 84 (1980).

[24] Speck, M.L. Compendium of methods for the microbiological examination of foods. Am. Public Health Assn., Washington, D.C. (1976).

by food service workers or equipment surfaces previously contacted by raw foods containing **Salmonella**. These contaminated foods may then be subjected to temperature fluctuations during storage and service that could foster the growth of **Salmonella** to unacceptable levels.[12]

Therefore, temperature control, good personal hygiene, and prevention of cross contamination are important to the prevention of **Salmonella** problems in food service systems.[12,1] Bryan has recommended that hazard analysis of food service operations be adopted for prevention of Salmonellosis.[12]

Testing for yeasts and molds is necessary for selected foods in which conditions (low pH, low moisture, or high salt or sugar content) are less favorable for bacterial growth. Baked goods such as breads and cakes need to be monitored because water activity conditions are favorable for molds and yeasts, but not bacteria.

B. Equipment/Container Testing

Contamination of food products can occur at any stage of preparation and service through contact with contaminated equipment, utensils, or containers. Thus, proper cleaning and sanitizing these sources of contamination must be an integral part of a food sanitation and safety program. Therefore, it is imperative that periodic microbial tests be performed to check the sanitization of equipment.[24] The testing should include, at minimum, total aerobic plate counts and coliform counts at all critical control points where contact with food occurs.

IX. GENERAL CONSIDERATIONS IN MICROBIOLOGICAL TESTING

The standard procedures for sampling and testing are described in the following five paragraphs.

(1) **Food Sample Collection, Handling, and Preparation.** The accurate estimation of the microbiological status of a food depends upon obtaining a representative sample. Frozen samples must be kept frozen while all other samples must be refrigerated to minimize the destruction and growth of the organisms present. All samples should be tested within 36 hours after sampling. For further details on sampling instruments and procedures refer to the "Compendium of Methods for the Microbiological Examination of Foods."[24]

(2) **Sampling in Testing for Equipment/Container Sanitization.** The sanitary condition of containers and equipment used in the CFPF or Remote Site can be determined by using either a revise solution method or surface contact method. Refer to Speck (1976) for sampling and testing procedures.[24]

(3) **Sampling Frequency and Size.** Statistically, an item should be sampled at least 3 times on separate occasions. If counts appear abnormally high (or low) on one occasion, subsequent sampling should be considered. Generally, samples of approximately 100 g are adequate.[25]

[25]J.R. Chipley. Personal communication. U.S. Tobacco Co., Nashville, TN (1981).

(4) Testing Time Required. Sufficient time must be allowed for weighing, mixing, serially diluting, and plating samples. Generally, a time period of three hours is required for two people to plate 10 samples in the five different media required for the microbiological testing listed in Table 2.[25]

(5) Detection and Enumeration of Injured Microorganisms in Cook-Freeze Foods. There is substantial evidence showing that sublethal food processes (e.g., cooking, freezing, drying, and cooling) can injure bacterial cells to the extent that they are not detected by procedures (given in Table 2) normally used for their enumeration. It appears that compounds added to selective media are generally inhibitory to the repair and multiplication of stressed cells. However, stressed but viable cells can potentially repair themselves in food or on equipment surfaces and thus can become potential public health hazards.[24] This fact has led to failure in accurately estimating bacterial counts in frozen foods.[24,26]

Therefore, it is imperative that foods processed in the proposed cook-freeze system be sampled and pretreated by methods developed to repair and enumerate injured bacteria in frozen foods. Procedures are given by Speck (1976) and were recently carried out by Cremer and Chipley (1977) in testing the microbiological quality of precooked frozen hamburger patties in a satellite foodservice system.[24,26] The general methods referenced in Table 2 can then be used.

X. FACILITY, EQUIPMENT, AND SUPPLY REQUIREMENTS FOR MICROBIOLOGICAL TESTING

In order to perform needed quality control sampling and microbiological testing of foods, basic laboratory equipment and supplies must be obtained and adequate work area and storage space provided. Table 3 lists equipment and supplies considered necessary by the American Public Health Association Intersociety/Agency Committee[24] and/or by J.R. Chipley,[25] a prominent food microbiologist. A current (1981) vendor (Fisher Scientific) catalog was used in estimating costs. Many items under supplies are disposable or otherwise not reusable (media, biochemicals) and will need to be replenished on a periodic basis. Refer to the vendor catalog (Fisher Scientific 81) or to the "Compendium of Methods for the Microbiological Examination of Foods"[24] for further details.

The work area provided for testing must be well ventilated but reasonably free from dust and drafts and well lighted (100 foot-candles at each work surface).[24] "The microbial density of air (bacteria, yeasts, and molds) in plating areas, as determined during plating by exposure of poured plates, should not exceed 15 colonies per plate during a 15 minute exposure."[24] Level, rigid chemical resistant tables with ample surface for pouring plates, etc. are needed. Storage area is required for cabinets, drawers, and shelves for protection and storage of

[26] M.L. Cremer and J.R. Chipley. Satellite food service system: time and temperature and microbiological and sensory quality of precooked frozen hamburger patties. J. Food Protection, 40:603–607 (1977).

Table 3

Basic equipment and supplies needed for food microbiology laboratory

	Price
Blender jars (1-pint capacity) (case of 4)	$ 128.
Blender base and blade assemblies (2 ea. @ $118)	236.
Balance, top loading (Sartorius 1204 MP)	2,880.
Incubator, still air (Fisher Model 350D)	995.
Autoclave (Sterilmatic Sterilizer Model STME)	2,875.
Hot air sterilizing oven (Precision Model 31542)	1,284.
Water bath, for keeping sterilized media liquefied (Precision Model 15–4555–5)	138.
Refrigerator (Laboratory Refrig./Freezer Precision Model 31225)	1,016.
Pipet washer, for nondisposable pipets (Stainless Steel Model 15–350–5)	220.
Colony Counter (Manual, Fisher Model 07–911–5)	295.
Microscope (Fisher, FS 19534–3)	1,115.
Microscope accessories	200.
pH meter (general-purpose digital; Fisher 13–637–610)	650.
Lab cart (Fisher 11–926)	147.
Spatulas and scoopulas (Fisher Cat. No. 14–430B) (4 ea. @ $8.00)	32.
Aluminum foil, for weighing food samples	10.
Wrapping paper, for autoclaving blade assemblies and jars, spatulas, scoopulas, etc.	15.
Milk dilution bottles, 90-ml and 99-ml graduations (Fisher 02–944–5) (case of 48)	87.

Table 3 (cont'd)

	Price
Escher stoppers (for 02–944 Milk Dilution Bottles, Fisher 02–945) (2 ea. pack of 12)	$ 20.
Pipets, wide bore, 1, 5, and 10 ml (Fisher Dual-purpose, ea. pk. of 12 @ $34.34)	103.
Pipets, glass, cotton-plugged, disposable, 1, 5, and 10 ml (1 ml, case of 400 @ $51.71; 5 ml, case of 721 @ $173.97; 10 ml, case of 600 @ $159.31)	385.
Sampling bags (Whirl-Pak), pre-sterilized (2 boxes of 500 @ $50.00)	100.
Erlenmeyer flasks 250, 500, and 1000 ml (250 ml, pk. of 6 @ $37.19; 500 ml, pk. of 6 $38.95, 1000 ml, pk. of 6 @ $45.02)	122.
Petri dishes, disposable, plastic, pre-sterilized (case of 500@ $61.40)	123.
Petri Dish Racks (case of 2)	95.
Portable cold storage container ("ice" chest) (Fisher Cat. No. 11–67518)	65.
Sampling instruments (covers, auger bit)	75. (est.)
Portable alcohol burners (Fisher 04–236, ea. @ $18.50)	37.
Stopwatch or timers (Fisher 14–656, ea. @ $25.25)	51.
Thermometers (Fisher 14–995–5B, ea. @ $6.75)	27.
Bunsen burners (Fisher, ea. @ $14.50)	29.
Pipet support racks for non-disposable pipets (Fisher 13–712–10, ea. @ $13.20)	27.
Swabs (case of 200)	55.
Screwcap test tubes (Fisher 14–932D, case of 192)	125.

Table 3 (cont'd)

	Price
Test tube racks (Fisher 14–809B, case of 4)	$ 32.
Microbiological inoculating loops and needles (loops, Fisher 13–102C, ea. @ $21; needles, Fisher 13–080B, ea. @ $24)	90.
Roccal, for disinfecting work areas	30. (est.)
Beakers, for weighing dry media (Fisher 02–599–17, pk of 10)	19.
Scissors and forceps (Scizzors, Fisher 14–275B, ea. @ $14.50; forceps, Fisher 10–295, pk. of 12 @ $28)	57.
Microscope slides (Fisher 12–550A, 10 gross)	77.
Talley counters (Fisher 07–905, ea. @ $12.15)	24.
Media	
Standard Methods Agar (BB1 B 11637, 1/lb. @ $11.70)	23.
Violet Red Bile Agar (BBL B 11807, 1 lb. @ $27)	54.
Brilliant Green Bile Broth (BBL B 11080, 1 lb. @ $28.60)	57.
Baird-Parker Agar Base (BBL B 11023, 1 lb. @ $95.30)	96.
Sulfite-Polmyxin-sulfdiazine agar	60. (est.)
Tryptose-sulfite-cycloserine agar	60. (est.)
Potato dextrose agar (BBL B 11650, 1 lb. @ $31.75)	64.
Biochemicals for subsequent identification of isolated microorganisms	400. (est.)
Miscellaneous reagents, chemicals, supplies	300. (est.)
Total	$15,205.

NOTE: Prices taken from Fisher Catalog – 1981.

equipment and supplies. Refer to the Fisher Scientific (or other vendor) catalog for selection of appropriate laboratory funiture to fit into existing or proposed facilities. Room space of at least 250 to 300 sq ft will be required to house the work and storage areas.

XI. ADDITIONAL RECOMMENDED TESTING HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP) QUALITY CONTROL

Temperature monitoring, sensory evaluation, and pH measurements are also recommended for quality control.

A. *Temperature Monitoring*

Routine temperature monitoring of food products and storage facilities from procurement to service must be carried out. Temperatures must be monitored at each critical control point in product flow. (see Table 4). Particular attention must be given to refrigerator and freezer temperatures to ensure proper temperatures are maintained and temperature fluctuations are avoided. The importance of temperature control cannot be overemphasized. Inadequate cooling has been associated with most of the foodborne diseases reported in the US from 1961 to 1976.[27] Inadequate cooling results when hot foods are not refrigerated immediately or when they are refrigerated in large quantities.[27] These practices slow the cooling process and allow for the growth of potentially harmful microorganisms.

B. Sensory Evaluation as a Measure of Quality

All foods should be routinely evaluated at the central supply storage center for raw product sensory qualities (visually for defects, and where applicable, for odor, taste, and textural defects, as well) and potential health hazards (e.g., ballooned or dented cans).

Routine sensory testing of finished products should also be done at the remote site(s) at points of service. Instances where defects or lowered acceptability are found by testing experts in the quality control lab or through consumer surveys among patrons should be investigated. The findings could be indicative of a number of problems: (1) poor quality raw food; (b) improper preparation, heat processing, storage, or serving practices; or (c) microbial growth or enzymatic activity leading to product deterioration. Therefore, this type of evaluation is critical in maintaining high quality, aesthetically pleasing and acceptable foods and as an adjunct to microbiological testing for detecting deterioration or public health hazards.

C. pH Measurements

Determining the pH of a food ingredient or finished product may be used as a tool to detect spoilage, deterioration, or susceptibility to growth of foodborne pathogens. Fluctuations

[27] F.L. Bryan. Factors that contribute to outbreaks of foodborne disease. J. Food Protection, 41:816–827 (1978).

in ingredients or processing can affect pH, and thus growth of bacteria. To inhibit staphylococcal growth, acid ingredients must be added in sufficient amounts to reduce the pH to 4.5, although little growth occurs below pH 5.[22] The acid taste, however, often makes these foods unpalatable to consumers. A typical food requiring pH monitoring is potato salad, a low acid food with a pH of about 4.6, which was a part of a recent hazard analysis carried out on party-pack foods.[28] Adequate quantities of mayonnaise or pickles will lower pH and control microbial growth.[22]

XII. PERSONNEL REQUIREMENTS FOR QUALITY CONTROL LABORATORY

A food technologist/microbiologist is needed to supervise and manage all aspects of the hazard analysis quality control program and related sensory testing outlined in this report. The individual should be knowledgeable and experienced in the fields of food quality control, food microbiology and sanitation, and sensory testing of foods. Experience in military or other large volume foodservice operations is desirable.

A minimum of two experienced laboratory technologists are needed to carry out routine food sampling and microbiological testing, temperature monitoring, sensory analyses, and other appropriate tests.

A registered dietitian is also highly recommended. In addition to ensuring that the nutritional quality of the food is maintained, the dietitian would be responsible for recipe modifications and development. The dietitian would also be expected to be in charge of routine sensory testing and questionnaire surveys. Experience in military or other large-volume foodservice operations is desirable.

Estimated GS grades and annual labor costs for these four personnel are given in Table 4.

Table 4

Labor costs for quality control lab

No.	Rank	Title	Salary/year
1	GS–12	Food Technologists/Microbiologist	$28,245
1	GS–11	Registered Dietician	$23,565
2	GS–05	Lab Technicians ($12,855)	$25,710
			$77,520
		Benefits	7,752
		Total	$85,272

[28] F.L. Bryan, M. Harvey and M.C. Misup. Hazard analysis of party-pack foods at a catering establishment. J. Food Protection, 44:118–123 (1981).

XIII. MODEL SYSTEM FOR HACCP QUALITY CONTROL MONITORING OF ENTREES

A general outline of entree product flow in a cook-freeze system is provided in Table 5. Critical control points in ingredient storage and equipment, personal sanitation, and temperature control are identified. General temperature/time recommendations are also made when applicable. Necessary microbiological tests are also indicated at selected critical control points.

XIV. RECOMMENDATIONS FOR HACCP QUALITY CONTROL MONITORING OF COOK-FREEZE ROAST BEEF

Beef has been implicated as the most frequently reported vehicle for foodborne disease outbreaks in the U.S. over the past decade.[10,29] Most outbreaks reported in the literature were caused by **Salmonella, Clostridium perfringens,** or Staphlococci, which proliferated as a result of improper hot-holding, cooling, or reheating in food service establishments. Outbreaks have also occurred in roast beef precooked in food processing plants.[10]

Cremer and Chipley (1980) and Bryan and McKinley (1979) have recently examined the preparation of roast beef in various types of food service establishments to identify potential critical points for foodborne disease hazards.[30,29] Data from both studies established the presence of known pathogens isolated from the raw beef, equipment, workers' hands, and cooked beef. Numerous opportunities were also identified for contamination and multiplication of the pathogenic bacteria. Emphasis in their recommendations were for strict control of internal temperatures during hot-holding, cooling, and reheating to minimize microbial growth and for prevention of contamination of beef from food handlers or equipment. Although neither study dealt specifically with a cook-freeze system, their findings were of considerable value in developing quality control procedures recommended in this report.

A study was recently carried out by US Army Natick scientists[31] to assess the food preparation practices at an Army CFPF where excessive contamination with **C. perfringens** had led to condemnation of roast beef. Their study determined that the cooked meat was held too long in a dangerous microbial growth zone (above 21°C, 70°F) during holding prior to slicing. They recommended that cooked roasts be quartered to speed cooling and refrigerated during holding before slicing, which was the step preceding addition of hot gravy and blast freezing in a cook-freeze system.

[29] F.L. Bryan and T.W. McKinley. Hazard analysis and control of roast beef preparation in foodservice establishments. J. Food Protection, 42:4–18 (1979).

[30] M.L. Cremer and J.R. Chipley. Time and temperature, microbiological, and sensory assessment of roast beef in a hospital foodservice system. J. Food Science, 45:1472–1477 (1980).

[31] W.E.M. Powers and D.T. Munsey. Bacteriological and temperature survey of ginger beef pot roast production at a central food preparation facility. J. Food Protection, 43:292–294 (1980).

Table 5

Critical control points, temperature time relationships, and microbiological testing for entrees in a commissary food service system

Location	Type	Critical Control Points: Ingredient Storage	Critical Control Points: Equipment Sanitation	Critical Control Points: Personal Sanitation	Critical Control Points: Temp Control	Recommended: Temp*	Recommended: Time*	Recommended Microbiological Testing**: Aerobic Plate Counts	Coliforms	Staph.	Clostridia	Molds/Yeast
Supply center storage	Chilled	x			x	≤7°C (44.6°F) mpt		x	x	(x)	(x)	(x)
	Frozen	x			x	≤−18°C (0°F) mpt		x	x	(x)	(x)	(x)
Central food preparation facility												
Storage	Chilled				x	≤7°C (44.6°F) mpt						
	Frozen				x	≤−18°C (0°F) mpt						
Preparation			x	x	x							
Cooking			x	x	x	≥60°C (140°F) variable						
Packaging			x	x	x			x	x	(x)	(x)	(x)
Freezing					x	≤−20°C (−4°F) 1.5 h						
Frozen Storage					x	≤−18°C (0°F) 8 wks						
Transportation					x	≤−18°C (0°F) mpt						
Remote Site												
Storage	Frozen				x	≤−18°C (0°F) mpt						
Thawing	Chilled				x	≤7°C (44.6°F) mpt		x	x	(x)	(x)	(x)
(Slicing)			x	x	x	≤7°C (44.6°F) mpt						
Reheating			x	x	x	74–77°C (165–171°F) or as specified						
Other (slicing)			x	x	x	≥60°C (140°F)						
Service			x	x	x	≥60°C (140°F)		x	x	(x)	(x)	(x)

*Boeng and David, 1977; Bryan and McKinley, 1979; mpt = minimum possible time; h = hours; wks = weeks.

**(x) — highly recommended; x — required at minumum.

Figure 4 shows a flow diagram outlining the preparation of whole cuts of roast beef in a typical cook-freeze system in a CFPF. The diagram is a model of the type used in a HACCP evaluation. Critical control points with the greatest chance for contamination or growth are noted with double borders.[12]

XV. COOK-FREEZE PROCEDURES

The following text discusses the step-by-step procedures required in the cook-freeze preparation of roast beef. The major consideration in each step is to prevent microbial contamination, survival, and growth that would lead to food infections or poisoning.

A. Supply Center Storage and Transportation to Central Preparation Area

There are four procedural considerations at this step.

1. Fresh cuts of beef are preferred over frozen beef because of subsequent frozen storage in a cook-freeze system.

2. Proper packaging in a plastic wrapping will retain wholesomeness and minimize microbial contamination.

3. It is desirable to hold beef under refrigeration at ≤ 2°C (36°F), or, if necessary, frozen at ≤ −18°C (0°F) for the shortest possible time period.

4. Storage temperatures and times should be monitored as part of HACCP procedures.[13]

B. Central Food Preparation Facility

1. **Storage and Preparation.** At this point hold fresh beef under refrigeration (≤ 2°C), or if prefrozen, thaw under refrigeration (≤ 2°C (36°F)).[29] Thawing at room temperature may raise meat temperature above 44°C (40°F) into the growth range for pathogens. Pathogenic bacteria generally will not grow during thawing in a refrigerator.[12]

Cooking prefrozen beef without thawing may produce meat that is not evenly cooked. Equipment and personnel sanitation should be controlled closely. Additional contamination can occur when beef is handled and panned before roasting.[12,13] Gloves should be worn by food service personnel to prevent contamination.

2. **Cooking.** Beef should be roasted in pans on racks in forced air convection ovens.[32] Roasting at 205°C (400°F) for one hour or until one of the 15 time-temperature combinations (e.g., 62.2°C, 144°F for 5 minutes) is reached in the geometric center of the roasts.[33] These

[32] U.S. Army Natick Labs. A proposed modern food service system for Fort Lewis, Washington. NATICK/TR–73–10–OR/SA 1972 (AD 751 196).

[33] U.S. Department of Agriculture. Cooking requirements for cooked beef. Fed. Reg. 43(85):18681–18682 (1978).

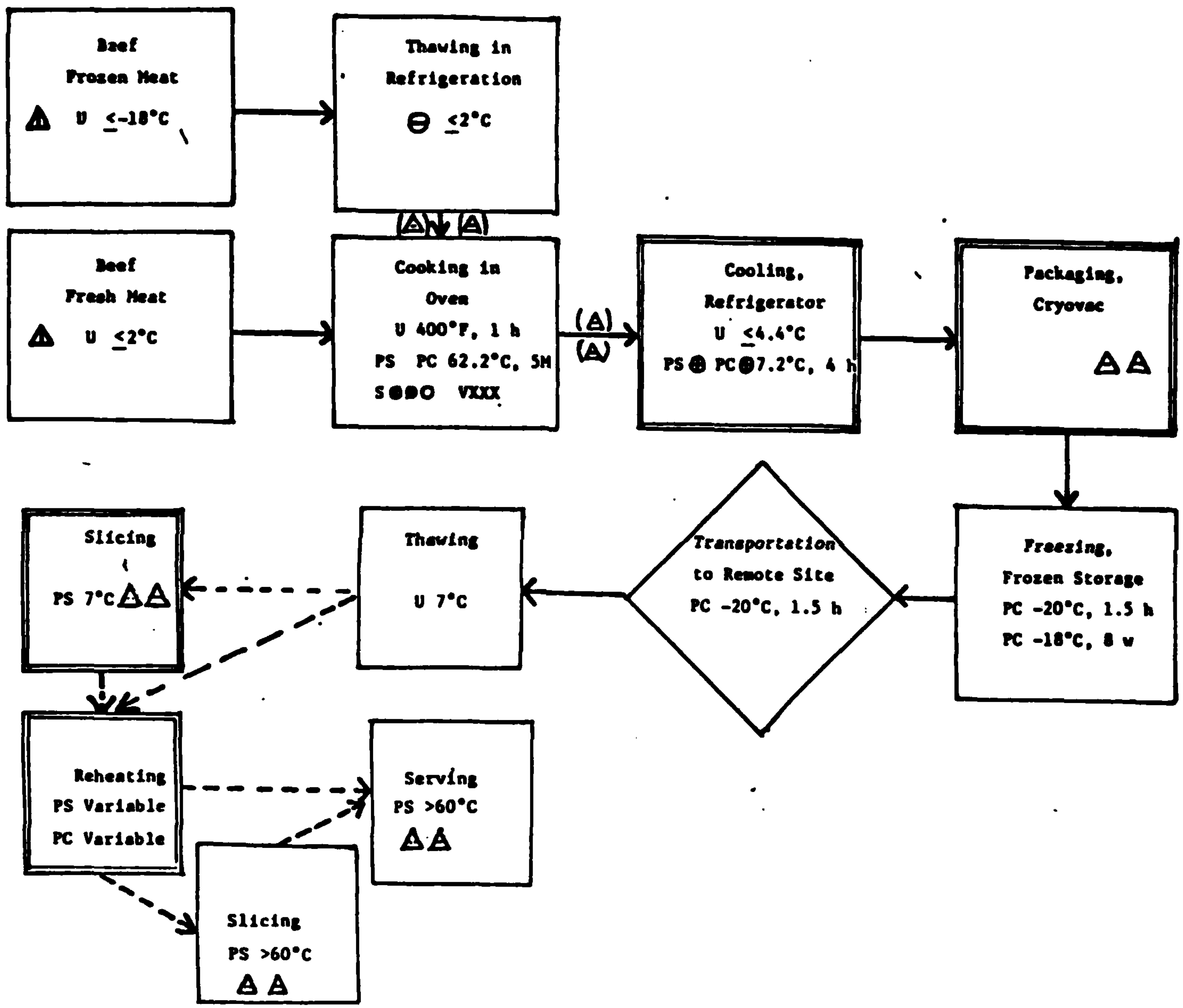

Figure 4. Typical flow process for preparation of roast beef in a commissary cook-freeze food service system

See Figure 1 of this report and Bryan (1981)[12] for explanation of symbols.

heat treatments are recommended based on reports showing they are sufficient to reduce the major types of **Salmonella** to acceptable levels.[10] **Salmonella** outbreaks have occurred in precooked roast beef prepared in processing plants when the beef was not exposed to heat treatments sufficient to kill **Salmonella**. Bryan (1980) points out, however, that **C. perfringens** spores and **S. aureus** (if in large numbers) would survive these precooked temperature-time heat treatments. However, use of higher heat treatments would increase degree of doneness and may lower acceptability, so strict adherence to sanitation prior to handling is critical to minimize the potential risk noted above.[10]

3. **Cooling.** Meat on racks should be removed from convection ovens, wrapped, and placed in a cooler equipped with vents and a refrigeration unit capable of blowing in air at a temperature of 4.4°C (40°F)[32] to facilitate cooling. Rapid cooling is a critical control procedure. It was found that more rapid cooling could be achieved by wrapping roasts in foil or plastic film and storing them singly on shelves or in shallow pans as opposed to putting them with other roasts in pans with lids.[29] If the roasts still do not cool from 60°C to 7.2°C (140 to 45°F) in four hours as required by FDA,[14] it may be necessary to cut the roast into more than one portion prior to wrapping to reduce bulk and increase surface area.[22]

4. **Packaging.** A Cryovac packaging process of cooled precooked beef is recommended. In this process, the roasts are wrapped in Cryorap, a moisture and oxygen proof copolymer.[5,6] The entrapped air is removed by vacuum treatment, the package sealed, and immersed in hot water to shrink the film closely around the beef. This process will diminish the risk of lipid oxidation and microbial contamination in subsequent handling and processing. This process is used in meat processing plants providing precooked roast beef to the foodservice industry.[34]

To avoid post-cooking contamination during packaging for other handling, sterile gloves should be worn and all work surfaces and equipment must be sanitized.

5. **Freezing and Frozen Storage.** Blast freezing in a tunnel freezer to −20°C (−4°F) in a short period of time (1.5 hr)[13] is recommended.

Roast should be stored at a temperature of ≤ −18°C (0°F) or below[14] for no more than eight weeks.[3] At this temperature there is minimal physical/chemical damage to the muscle tissue.

C. Transportation to Remote Site

The two considerations at this point are sanitation and temperature.

1. Proper sanitation and personnel hygiene are needed in handling during transportation (US DHEW, 1976; Bryan, 1979).[14,35]

2. Temperature during transportation should be maintained at ≤ −18°C (0°F) without fluctuations to higher temperatures to avoid potential freeze/thaw damage to the meat.

[34] J. Alpert. Personal communication. Herbert Alpert Meat Co., New Haven, CN (1981).

[35] F.L. Bryan. Prevention of foodborne diseases in foodservice establishments. J. Environ. Health, 41:198–206 (1979).

D. Remote Site

1. **Thawing of Frozen Stored Beef.** Frozen meat should be thawed in refrigerated units at a temperature not to exceed 7.2°C (45°F).[14] Otherwise, pathogenic bacteria can multiply, if present, when food is thawed.

2. **Slicing (Optional).** If slicing is done at this point, the cryovac packaging film should be removed and slicing carried out at a temperature not exceeding 7.2°C (45°F). Slicing of meat when cold will inhibit bacterial growth and increase the yield.[31]

Adherence to equipment sanitation and personnel hygiene practices is critical in the prevention of contamination during slicing and handling of meat slices.[14,35]

3. **Reheating.** There are two approaches available for reheating.

One, the thawed meat can be removed from packaging and placed in pans in forced air convection ovens and heated to at least 74°C (165°F).[12,29,13] This temperature assures destruction of vegetative foodborne pathogens. Reheating below this temperature has been implicated in many foodborne disease outbreaks involving roast beef.[29] However, there will be a trade-off in lowered sensory quality and increased nutrient losses because the meat will be well done.

Secondly, the meat surface can be pasteurized.[29] These methods can be used for roasts that are not subject to internal contamination. There are several methods of surface pasteurization including: (1) immersion of roast in boiling stock or reheating roasts in stock that reaches boiling during heating; (2) heating foil-wrapped roasts or slices of roasted meat for sufficient time (usually an hour or more) in ovens with temperatures at least 165°C (325°F); (3) heating whole roasts or sliced individual portions of meat in boiling-water-heated-steam tables that have sliding covers over the insert pan and perforated bottom pans for sufficient time (usually an hour or longer); (4) immersing slices of roast beef in hot (92.8 to 100°C (199 to 212°F)) stock; or (5) heating slices of beef in enclosed steam-injection steamers. Some of the above approaches would result in reheated meat that could be served as medium rare or as cold slices.[29]

4. **Service (including slicing).** The temperature of roasts for service and slicing (if done at this stage) must be maintained at 60°C (140°F) or higher.

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